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Disability, wages, and commuting in New York

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ABSTRACT

In the U.S., substantial employment and wage gaps persist between workers with and without disabilities. A lack of accessible transportation is often cited as a barrier to employment in higher wage jobs for people with disabilities, but little is known about the intraurban commuting patterns of employed people with disabilities in relation to their wage earnings. Our study compares wages and commute times between workers with and without disabilities in the New York metropolitan region and identifies the intraurban zones where residents experience higher inequities in wage earnings and commute times. We obtained our data from the Public Use Microdata Sample (PUMS) of the American Community Survey (ACS) for the 2008–2012 time period. We used linear mixed-effects models and generated separate models with log hourly wage or one-way commute time as the dependent variable. We find significant differences in wages and commute times between workers with and without disabilities at the scale of the metropolitan region as well as by intraurban zone. At the metropolitan scale, disabled workers earn 16.6% less and commute one minute longer on average than non-disabled workers. High commute and wage inequalities converge in the center, where workers with disabilities are more likely to use public transit, earn 17.1% less, and travel nearly four minutes longer on average than workers without disabilities. These results suggest that transport options are less accessible and slower for disabled workers than they are for non-disabled workers. Our findings indicate a need for more accessible and quicker forms of transportation in the center along with an increased availability of centrally located and affordable housing to reduce the disability gap in wages and commute times. We also find that workers with disabilities generally seek higher wages in exchange for longer commute times, but the results differ by race/ethnicity and gender. Compared to white men, minority workers earn much less, and white and Hispanic women have significantly shorter commute times. Our findings offer new geographic insights on how having a disability can influence wage earnings and commute times for workers in different intraurban zones in the New York metropolitan region.

1. Introduction

People with disabilities have historically had restricted access to the labor market and their adverse economic circumstances – borne of discrimination on the basis of disability status and subsequent inequities in wages – are a global problem (Mitra et al., 2011.; Schur, 2002; Lindsay and Houston, 2011). In the U.S., among working-age people, inequities in workforce participation or employment persist along the axis of disability status (Schur, 2002; Sevak et al., 2015). In 2013, only 34% of individuals with disabilities in the labor force (i.e., currently working or actively looking for work) were employed – a much lower rate than their non-disabled counterparts, of whom 74% were employed (Brucker and Houtenville, 2015). Disability employment gaps also vary based on other axes of social differentiation, including race, marital status, and educational attainment. For example, Black Americans, American Indians, and Alaska Natives are overrepresented among the disabled population, and have lower workforce participation and lower wages (Kaye, 2010). Sevak et al. (2015) find greater inequities for men and for individuals who are black or white, 30–59 years of age, not married, and have an Associate's degree or less education (Sevak et al., 2015). Employment rates for people with disabilities are shaped by a multitude of factors, including transportation

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access, individual competencies, health-related constraints, employer attitudes regarding disability, job opportunities and requirements, the availability of workplace accommodations and other employment resources, and the structure of the public disability benefit system (Brucker and Houtenville, 2015; Crudden et al., 2005; Gewurtz et al., 2016; Vornholt et al., 2018). These factors are perpetuated by ableism (i.e., the structural and societal devaluation of and discrimination against disabled people) and have led to low employment rates and negative financial outcomes for people with disabilities (England, 2003; Gleeson, 1999; Sarrett, 2017).

More importantly, employment alone is not an economic panacea for people with disabilities because they are often sorted into 'low' and 'medium' skill occupations, which are more vulnerable to job losses during economic downturns (Kaye, 2010). They are consequently paid much lower wages than people without disabilities, which brings about and reinforces pay inequities. Compared to non-disabled workers, disabled workers earn 10 to 25% less on average in the U.S. (Brucker and Houtenville, 2015; Gunderson and Lee, 2016; Schur, 2002). The pay gap remains significant across age groups and levels of education for both women and men (Kruse et al., 2018). The reasons for these wage inequities include the changing composition of jobs over time and employer discrimination. People with disabilities experienced a decline in full-time employment from 12% in 1981 to less than 6% in 2014 (Brucker and Houtenville, 2015). Workers with disabilities are also less likely to be employed in higher paying occupations – they have been generally overrepresented in service and blue-collar jobs while underrepresented in managerial and professional positions (Kruse et al., 2018; Maroto and Pettinicchio, 2014).

Although the 1990 Americans with Disabilities Act (ADA) prohibits discrimination against people with disabilities and was expected at the outset to lead to improved access and community participation, disabled people continue to confront workforce participation barriers and inaccessible built environments impeding their mobility (Bezyak et al., 2017; Maroto and Pettinicchio, 2015). Twenty-five years after the passage of the ADA, the employment rate for people with disabilities steadily declined over time while the employment rate for non-disabled individuals remained relatively stable (Maroto and Pettinicchio, 2015). The persistence of disparities in workforce participation after the ADA, despite gains in educational attainment among disabled people, points to the limitations of lawsuits as a primary means of enforcing anti-discrimination legislation (Maroto and Pettinicchio, 2015). Furthermore, post-ADA improvements to the accessibility of built environments have been too gradual. In the U.S., many communities still do not have ADA transition plans for pedestrian infrastructure (Eisenberg et al., 2020) and many public transit systems continue to be widely inaccessible, thus constraining the mobility of people with disabilities, their employment prospects, and their participation in their communities (Bezyak et al., 2017).

A lack of accessible transportation is often cited as a barrier to employment for people with disabilities (Bezyak et al., 2019; Lubin and Feeley, 2016), but much less is known about the travel patterns of disabled individuals when they are employed and how their commutes relate to the localities where they live and work. In the general population, there is strong evidence to demonstrate that transportation and commuting patterns greatly influence people's job access and wage earnings (Preston and McLafferty, 2016; Kim et al., 2012), but these studies do not address disability. The few studies that investigate the commute patterns of people with disabilities include Deka and Lubin (2012) and Brucker and Rollins (2019), who found commute times to be similar between workers with and without disabilities in New Jersey and across the U.S., respectively. Another study by Farber and Páez (2010) examined adults with disabilities alone and they found public transit users to have longer commute distances to work compared to car users across Canada. While these studies controlled for multiple sociodemographic factors affecting commute times, none accounted for intraurban geographies, thus overlooking how local geographic contexts influence commute times. Brucker and Rollins (2019) included a dummy variable for metropolitan status while the other two studies did not consider geography in their statistical models (Deka and Lubin, 2012; Farber and Páez, 2010). Geographic contexts, especially residential contexts, differ in the numbers, types, and locations of job opportunities; the availability of social and employment services; and transportation access and cost – all of which shape workers' commuting decisions and wage earnings. Research on the entire working population shows disparities in commute time, distance, and mode across residential contexts (Preston and McLafferty, 2016; Hu, 2015; Lee et al., 2018; Sultana and Weber, 2014), and it is likely that similar disparities exist for disabled workers. More empirical work on the spatial heterogeneity of wage earnings and commute patterns would enhance our current understandings of how geographic conditions influence the socioeconomic inequities experienced by workers with disabilities. Disabled workers regularly experience indignities in the form of lower wages and inaccessible built environments. If they have longer or more challenging commutes to work, this represents an additional tax on a group that has already been systematically excluded from gainful employment, and it is therefore important to identify where exactly these injustices occur to better address them. A greater attention to locational differences would generate useful information for local policy and planning initiatives, including the identification of specific neighborhoods that most need improvements to transportation infrastructure, housing development plans, and workplace discrimination.

Regarding mode of transportation to work, public transit use is low among U.S. workers; and for those who rely on public transportation, commutes are more taxing. In the U.S., disabled and non-disabled workers have comparably low rates of public transit use: 5.5% and 5.1%, respectively (Brucker and Rollins 2019). Among people with disabilities, employed individuals use public transit less than non-workers (Loprest and Maag, 2001). For disabled individuals, reasons to avoid public transportation include physical inaccessibility and long commute times (Wong, 2018b). Since public transit users have considerably longer work commutes than car users (Farber and Páez, 2010), public transit use is an important covariate to control for in statistical analyses of commute times.

Associations between sociodemographic factors and commute time and distance have been widely studied. Gender and race have important links to commuting, with white women often working closer to home than their male counterparts (Hanson and Pratt, 1995). Women's higher burden of domestic responsibilities and lower wages account in part for these gender disparities (Preston and McLafferty, 2016; Craig and van Tienoven, 2019). However, similar gender disparities have not been found for Black, Latinx, and Asian workers (McLafferty and Preston, 1992; Crane, 2007; Johnston-Anumonwo, 2014; Mauch and Taylor, 1997). Research shows that people who work in low-wage positions often work close to home (Kim et al., 2012), although recent evidence suggests that in cities undergoing rapid gentrification, low-wage workers, especially minority workers, increasingly endure long commuting trips (McLafferty and Preston, 2019). We anticipate that these sociodemographic characteristics will intersect in complex ways with intraurban location to shape wages and commute trips for people with disabilities.

Our study has three main research questions: (1) how do wages and commute times differ between workers with and without disabilities in the New York metropolitan region, (2) how do these disparities vary between urban and suburban areas of the metropolitan region, and (3) how are wages and commute times influenced by sociodemographic and geographic factors for workers with disabilities alone? This research provides new empirical insights into the conditions of employment and commuting for urban and suburban residents with disabilities in a major U.S. metropolitan region. We also consider how gender, race, and transportation mode, factors significant in previous research (Preston and McLafferty, 2016; Craig and van Tienoven, 2019; Deka and Lubin, 2012; Kim et al., 2012), intersect with disability to influence wage and commuting trends.

2. Materials & methods

2.1. Study area

The study area for this research is the New York metropolitan region, an area centered around New York City. With a population of more than 19 million, the region is the most populated in the U.S., a major economic node of integrated housing and labor markets (U.S. Census Bureau, 2010), and the largest commuting region in the U.S. Jobs are concentrated in Manhattan, the region's center which receives 1.6 million commuters each workday (U.S. Census Bureau, 2013). The region stands out for its extensive transit network that includes subway, bus, and light rail networks, and for its diverse residential settings that range from dense, high-rise neighborhoods in the center to low-density, exurban zones on the region's fringe. The size and geographic diversity of the region make it an important empirical case study for investigating intraurban wage and commuting trends among workers with disabilities. A focus on New York will generate insights on the wage and commuting patterns of disabled workers in the largest U.S. metropolitan region. In addition, our focus on a single metropolitan region enables us to tease out intraurban patterns that are often neglected in studies based on national data.

In recent decades, the New York metropolitan region experienced distinctive changes in employment and commuting across three intraurban zones: the center (i.e., Manhattan), inner ring, and suburbs (Fig. 1). From 2000 to 2009, employment increased in the center and suburbs (Moss et al., 2012) but decreased in the New Jersey counties closest to Manhattan (Preston and McLafferty, 2016). The relocation of jobs shaped the relationships between residential location, wage earnings, and commute time. In 2010, workers residing in the center received the highest wages and had the shortest commutes, with commute times generally declining alongside increases in hourly wages. In contrast, workers living in the inner ring and suburbs had longer commutes in exchange for higher wages (Preston and McLafferty, 2016).

Compared to the rest of the U.S., workers in the New York metropolitan area are more likely to use public transportation to commute due to the accessibility of mass transit coupled with slow driving times (Moss et al., 2012). Nonetheless, research showed that the customary mode of transportation to work varies by residential location and among racialized groups. In Manhattan, most residents used public transit or walked to work. A higher proportion of workers in the inner ring and suburbs commuted by car. White workers were more likely to drive to work while workers of other racialized groups were more likely to utilize public transportation (Preston and McLafferty, 2016). To date, research on employment and commuting in the New York metropolitan region has yet to investigate how having a disability might influence these patterns.

2.2. Data

All data on employed residents in the study area were obtained from the Public Use Microdata Sample (PUMS) of the American Community Survey (ACS) for the 2008–2012 time period. Of all the national surveys conducted in the U.S., the ACS collects data that is most representative of the working population. In the original dataset, each year contains a

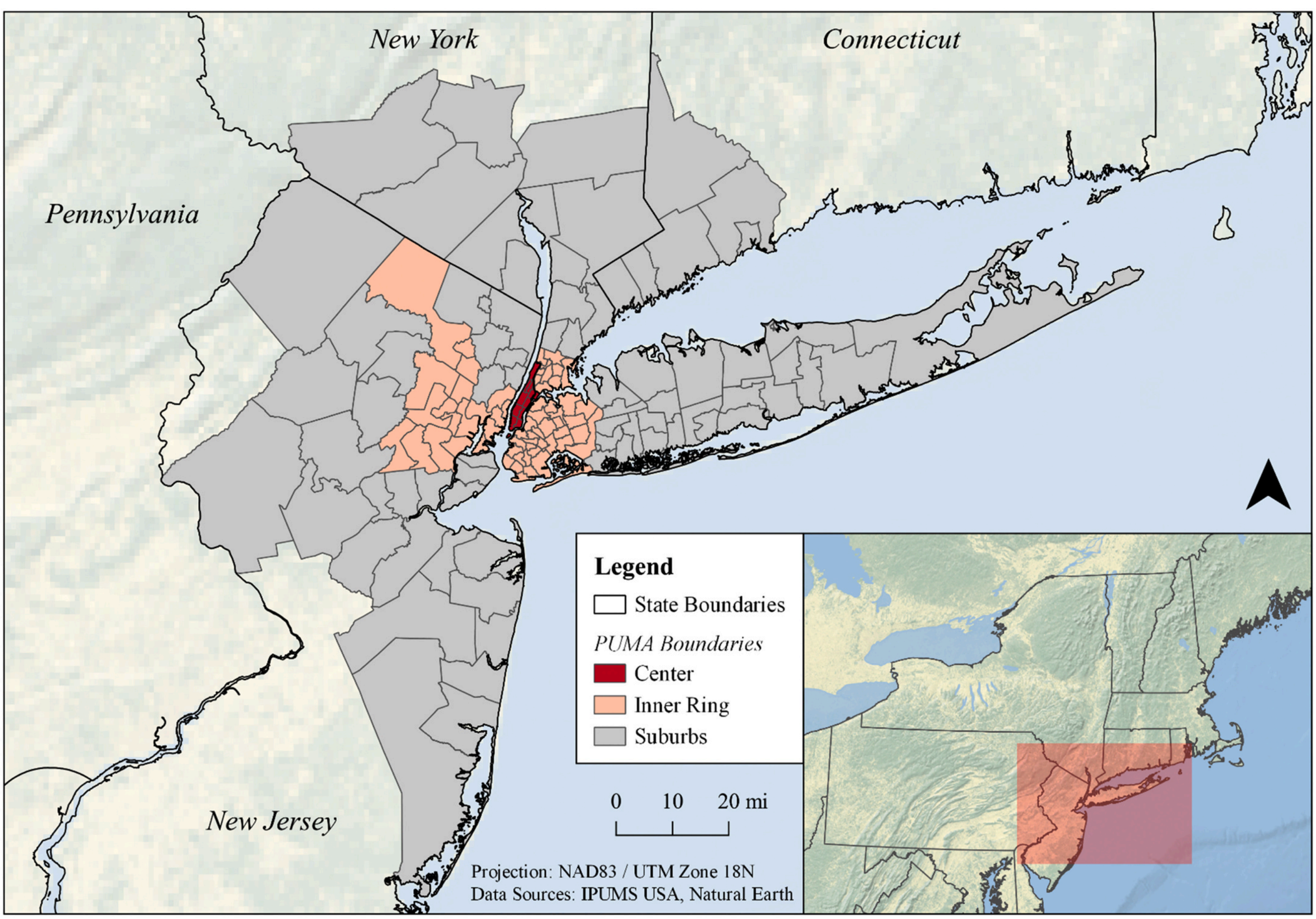

Fig. 1. PUMA boundaries in the New York metropolitan region.

1% sample of the total population in the New York metropolitan region and the pooled five-year dataset represents approximately 5% of the study area's total population. Our sample consists of all individuals who received wage or salary income in the past 12 months. We omitted self-employed people, people who worked at home, and individuals whose estimated hourly wage was < $1 per hour. The final sample size is 373,521 workers, of which 12,922 individuals report having a disability (approximately 3.5% of the total). We refer to the 2008–2012 dataset as the 2010 PUMS for brevity and to highlight the dataset's midway time point. Individuals in PUMS are nested in Public Use Microdata Areas (PUMAs), which are the geographic areas that were statistically generated for public dissemination of PUMS without violating individual privacy. Each PUMA contains at least 100,000 individuals.

The study period overlaps with the macroeconomic contraction known as the Great Recession. During the 2007–2009 recession, there was widespread restructuring in both housing and labor markets, which jointly and independently affected workers, especially lower- and middle-class workers. Unemployment rates in the U.S. were the highest since 1983, with disproportionate losses borne by disabled workers, whose share of the total workforce declined by 9% (Kaye, 2010). Employed individuals with and without disabilities experienced similar declines in average annual earnings over the course of the recession, but large disparities in earnings remained by disability status (Maroto and Pettinicchio, 2015). The commuting patterns of people with disabilities during this time period have not been studied much. We know that the average one-way commute time in the U.S. dipped by a fraction of a minute during the recession (Ingraham, 2019) and that nationally, disabled and non-disabled workers had similar commute times (Brucker and Rollins 2019; Deka and Lubin, 2012).

We use the ACS's definition of disability as a binary variable (presence or absence of a 'deficit'), which is based on responses to items about limitations in hearing, vision, ambulatory, cognitive, independent living, and self-care capacity (Kaye, 2010). However, we recognize that the experience of disability is varied and relational. Disability type and the severity of one's disability and/or health status interact with socioeconomic status and educational attainment to shape a person's perceived suitability of employment and level of compensation (Schur, 2002).

Following Preston and McLafferty, 2016, we divided the region into three zones that represent the region's diverse residential and transportation environments. The *center* consists of Manhattan, the region's largest concentration of job opportunities and the focal point of the region's transportation networks. Although the study region is polycentric, Manhattan stands out as the region's single largest employment center, accounting for almost one-quarter of the region's jobs in 2010 (Preston and McLafferty, 2016). Manhattan also represents a distinctive residential context, with its exceptionally high population and commercial densities and extensive public transit networks. The *inner ring* that includes Brooklyn, Queens, and the Bronx in New York City and some adjacent areas of New Jersey comprises dense residential areas that are connected to Manhattan via public transit (Fig. 1). The remaining areas are designated as *suburbs*. Although heterogeneous, these areas typically have low population densities, limited public transportation, and require a long or expensive commuting trip to reach jobs in Manhattan (Preston and McLafferty, 2016).

We anticipate that the three zones may give rise to differences in wages and commute times for people with disabilities due to disparities in residential density and transit availability. Compared to locations in the center and urban ring, suburban areas with lower population density have fewer public transit options and less frequent timetables, thus constraining the mobilities of disabled suburban commuters who rely on public transit (Wong, 2018a; Wong, 2018b). In general, transportation unavailability and inaccessibility are major mobility and commuting challenges for many disabled individuals (Bezyak et al., 2017; Lubin and Deka 2012). Unlike non-disabled individuals, disabled commuters regularly contend with physical barriers and attitudinal issues during their travels that are related to their impairment and impede their mobility (Bezyak et al., 2017; Wong, 2018b). For example, when using public transit, individuals with mobility or vision impairments often encounter unavailable or inoperable lifts or ramps and drivers who do not provide stop announcements (Bezyak et al., 2017).

To investigate the pay and commute time disparities between workers with and without disabilities, our main outcome variables are log hourly wage and commute time. The 2010 PUMS contains total wage or salary income in the past 12 months. We calculated hourly wage, which is equal to the wage and salary earnings divided by the estimated number of weeks worked and divided by the typical hours worked per week. We then calculated and used log hourly wage due to a positive skew in hourly wages. Commute time is the one-way, self-reported time spent traveling to work on a typical day, in minutes.

2.3. Methods

Our two dependent variables are log hourly wage and one-way commute time to assess differences between workers with and without disabilities in terms of wages and their work commutes, respectively. We used linear mixed-effects models (LMMs) with PUMA-level random intercepts to account for the non-independence of observations within PUMAs. Separate LMMs were constructed for three distinct dependent variables (log hourly wage and one-way commute time for the total sample, and one-way commute time for disabled individuals alone) and four different geographies (metropolitan region, center, inner ring, and suburb). Independent variables in the LMMs are individual characteristics that include age, education level, race/ethnicity, gender, disability, marital status, part-time work status, public assistance status, and public transit use; and PUMA-level attributes that include work and residential locations. In total, we generated 12 models using the 2010 PUMS data.

LMMs are useful for representing, estimating, and accounting for the relationship between data nested at different levels, such as individuals and the groups that they belong to (Subramanian et al., 2003). In our case, we have individuals and the PUMAs that they reside in. A conventional practice is to fit a fixed effects model at one level but not the other, which can lead to individual or ecological fallacies (Subramanian et al., 2003). Another option is to fit separate fixed effects models at the individual and group levels. An LMM is a streamlined approach because it combines these two steps into one (Gelman and Hill, 2007). Yet another alternative is to include dummy variables belonging to the group level as predictors in a fixed effects model to account for the nested data structure (McNeish and Kelley, 2019). However, this approach is better suited when the number of groups is small (i.e., under 20 or 30) (Brauer and Curtin, 2018; McNeish and Kelley, 2019), whereas our sample contains 142 groups. Furthermore, fixed effects models have limiting assumptions and constraints. Fixed effects models treat group-level variables as fixed variables, only explicitly modeling within-group variation and assuming to capture all the variability at the group level. Fixed effects models also do not assume that groups are sampled randomly, therefore results may not be generalizable to other groups that are not included in the models. Unlike fixed effects models, mixed-effects models do not have these limiting assumptions and can directly estimate group-level predictors and between-group variability without having to include an unwieldy number of parameters (Brauer and Curtin, 2018; McNeish and Kelley, 2019). These are the advantages for which we choose LMMs over simple linear regressions.

LMMs extend simple linear regressions to include both fixed and random effects. In our models, the *fixed effects* are the constant slopes and the *random effects* are the varying intercepts for each PUMA. In other words, the intercept is allowed to vary for each PUMA. All PUMAs are assumed to have the same slope, but some may have a higher or lower intercept than the average relationship for all PUMAs. We calculated two types of R^2 (marginal R^2 and conditional R^2) to quantify the variance attributable to the different types of effects. Marginal R^2 is the share of the total variance explained by the fixed effects and conditional R^2 is the proportion explained by both the fixed and random effects (Nakagawa et al., 2017).

To quantify the wage gap between workers with and without disabilities at four discrete geographies (i.e., the entire metropolitan region and the three intraurban zones), we generated four separate LMMs with log hourly wage as the dependent variable. Each model represents a distinct residential area. The first model pertains to the entire study area and the other three models apply to the intraurban subregions: center, inner ring, or suburb. For these LMMs, we included an interaction covariate of female and disabled to better assess the effects of gender and disability status on wages. We also calculated the exponentiated regression coefficients to present the percent increase or decrease in wages in one group relative to its reference group.

To estimate the disparity in commute time between workers with and without disabilities at the scale of the metropolitan region as well as within each distinct intraurban zone, we constructed LMMs with one-way commute time as the dependent variable. We generated four models, one each for the geographic zones discussed earlier. We experimented with including an interaction term for female and disabled, but it was not statistically significant and did not change the results, so we did not include it in the final models.

Our final research objective is to assess the impacts of socioeconomic and geographic factors on the relationship between commute time and wages for workers with disabilities alone in each of the four geographies. A focus on workers with disabilities allows us to investigate closely the economic and social influences on their commuting times at different geographic scales. Separate models were created for each geographic zone with commute time as the dependent variable.

We generated models at different geographic scales: at the scale of the metropolitan region and for each of the three intraurban zones. The models enable us to assess how inequalities in commuting and wages based on disability status vary among geographic context. It is possible for associations to be present in the center, but not in the inner ring or suburbs, and vice versa. By identifying where disparities in commuting and wages are highest, we can better understand the local causes driving disparities and pinpoint the localities where policy changes are critical.

3. Results & discussion

3.1. Descriptive statistics on hourly wages and commute time

From the descriptive statistics alone, we find striking differences in hourly wages between workers with and without disabilities (Table 1), corroborating the wage gaps reported previously in the literature (e.g., Brucker and Houtenville, 2015; Gunderson and Lee, 2016; Schur, 2002). We focus on median hourly wages because the mean

Table 1
Hourly wage & commute time descriptive statistics.

	Entire metro	Center	Inner ring	Suburb
	Median	*Median*	*Median*	*Median*
Hourly wages (USD)				
With disability	17.95	20.27	16.34	19.23
Without disability	21.92	26.79	19.23	24.03
Commute time (min)				
With disability	30	30	30	20
Without disability	30	30	30	25
	%	%	%	%
Public transit users				
With disability	28.0	63.9	44.1	11.0
Without disability	27.7	61.9	45.7	10.9

calculations are influenced by a positive skew in the data and an outlier in the center that consists of one disabled worker earning extremely high wages. The largest wage gap is in the center, followed by the suburbs and the inner ring. In the center, workers without disabilities earn a median hourly wage of $26.79 while workers with disabilities earn $20.27 – a difference of $6.52 an hour. In the suburbs, the difference in median hourly wage is $4.81 an hour – workers without disabilities earn $24.04 while workers with disabilities earn $19.23. The disparity in median hourly wage is lowest in the inner ring at $2.88 an hour, with non-disabled workers earning $19.23 compared with disabled workers' median hourly income of $16.35.

At the scale of the metropolitan region where we do not find major differences in the average one-way commute times between workers with and without disabilities, our findings are similar to those reported at national and state levels (Brucker and Rollins 2019; Deka and Lubin, 2012; Farber and Páez, 2010). What is unusual is that we find slight intraurban differences (Table 1). In the suburbs, the median commute time for disabled workers is five minutes shorter than it is for non-disabled workers.

Consistent with national statistics indicating low levels of public transit use across the U.S. regardless of disability status (Brucker and Rollins 2019), public transit use is not significantly different between disabled and non-disabled workers at the metropolitan scale. However, we do find small intraurban differences in public transit use (Table 1). In the center, a higher percentage of disabled workers rely on public transit, whereas the disparity is reversed in the inner ring.

3.2. Wage gap findings

3.2.1. Disability

After controlling for economic, demographic, and geographic factors, we find wage disparities by disability status and gender in the New York metropolitan region, with considerable wage variation by residential location. Across the metropolitan region, workers with disabilities earn 17% less on average than comparable workers without disabilities (Table 2a, Model 1). This finding is within the bounds of existing disability wage gaps, that range from 10 to 25% in previous U. S. studies (Brucker and Houtenville, 2015; Schur, 2002).

There are intraurban variations in the wage disparity between disabled and non-disabled workers. Workers residing in the center and suburbs experience the largest wage gaps followed by workers in the inner ring. Compared to workers without disabilities, workers with disabilities living in the center earn on average 17% less in hourly wages (Table 2a, Model 2) and those living in the suburbs earn 19% less (Table 2b, Model 4). In the inner ring, the wage disparity is smallest as residents with disabilities earn 12% less on average than workers without disabilities (Table 2b, Model 3).

The wage disparity is also gendered. Compared to non-disabled male workers, disabled women earn 24% less across the metropolitan region (Table 2a, Model 1). A similar and significant wage gap also emerges in the model for the suburbs (Table 2b, Model 4). Disabled female workers also earn 11% less than non-disabled female workers in the entire metropolitan region and in the suburbs. Gender disparities in wage earnings are widely recognized within the general population, with women earning less than men (Preston and McLafferty, 2016; Craig and van Tienoven, 2019); however, less is known about the intersection of gender and disability. Our results reveal that being female compounds the economic penalty associated with having a disability (Brucker and Rollins 2019; Gunderson and Lee, 2016). The findings also vary by zone, indicating that female workers with disabilities who live in the suburbs face more wage discrimination than they do in other parts of the metropolitan region.

Intraurban inequalities in the disability pay gap are important because they reveal geographic inequities in economic mobility and financial security. In Manhattan, the central zone, where wages are the highest in the metropolitan region, workers with disabilities earn much

Table 2
LMM results with log hourly wage as the dependent variable.

a. Metro & center

Variable	Model 1: Entire Metro				Model 2: Center			
	Estimate	95% CI	Percent	P-Value	Estimate	95% CI	Percent	P-Value
Fixed Effects								
Disability Status								
Yes	−0.18	−0.20, −0.16	−16.6	< 0.001	−0.19	−0.28, −0.10	−17.1	< 0.001
No	ref							
Gender								
Male	ref							
Female	−0.16	−0.16, −0.15	−14.4	< 0.001	−0.19	−0.21, −0.17	−17.4	< 0.001
Female x Disabled	0.07	0.04, 0.09	6.9	< 0.001	0.05	−0.06, 0.16	4.8	0.43
Race/Ethnicity								
White	ref							
Black	−0.07	−0.08, −0.06	−6.5	< 0.001	−0.11	−0.14, −0.07	−10.3	< 0.001
Hispanic	−0.16	−0.16, −0.15	−14.5	< 0.001	−0.17	−0.20, −0.13	−15.2	< 0.001
Asian	−0.17	−0.17, −0.16	−15.3	< 0.001	−0.14	−0.17, −0.11	−13.2	< 0.001
Educational Attainment								
Less than HS	−0.32	−0.33, −0.31	−27.4	< 0.001	−0.37	−0.42, −0.33	−31.2	< 0.001
HS to Associate's Degree	ref							
Bachelor's Degree or Higher	0.48	0.47, 0.48	61.4	< 0.001	0.62	0.60, 0.65	86.5	< 0.001
Marital Status								
Married	0.19	0.19, 0.20	21.1	< 0.001	0.18	0.16, 0.20	19.4	< 0.001
Not Married	ref							
Work Status								
Part-Time	−0.31	−0.31, −0.30	−26.4	< 0.001	−0.28	−0.31, −0.24	−24.1	< 0.001
Full-Time	ref							
Public Assistance Recipient								
Yes	−0.26	−0.28, −0.23	−22.5	< 0.001	−0.49	−0.61, −0.37	−38.7	< 0.001
No	ref							
Public Transit Use								
Yes	−0.08	−0.08, −0.07	−7.4	< 0.001	0.01	−0.01, 0.03	1.3	0.27
No	ref							
Work Location in Manhattan (at PUMA-level)								
Yes	0.21	0.20, 0.22	23.3	< 0.001	0.02	−0.01, 0.05	2.3	0.12
No	ref							
Home Location (at PUMA-level)								
In Center	0.01	−0.05, 0.08	1.5	0.65				
In Inner Ring	−0.08	−0.11, −0.05	−7.7	< 0.001				
In Suburbs	ref							
Age (years)	0.01	0.01, 0.01	1.1	< 0.001	0.01	0.01, 0.01	1.3	< 0.001
Commute Time (minutes)	0.002	0.002, 0.003	0.2	< 0.001	−0.001	−0.002, −0.001	−0.1	< 0.001
Random Effects								
PUMA-Level Intercept	0.009	0.007, 0.012	0.9		0.027	0.013, 0.091	2.8	
R^2 (marginal)		0.307				0.261		
R^2 (conditional)		0.321				0.293		
AIC		766,693.5				56,005.22		
BIC		766,910.1				56,150.75		

b. Inner ring & suburb

Variable	Model 3: Inner Ring				Model 4: Suburb			
	Estimate	95% CI	Percent	P-Value	Estimate	95% CI	Percent	P-Value
Fixed Effects								
Disability Status								
Yes	−0.13	−0.15, −0.10	−12.0	< 0.001	−0.21	−0.23, −0.19	−18.8	< 0.001
No	ref							
Gender								
Male	ref							
Female	−0.09	−0.10, −0.09	−8.8	< 0.001	−0.19	−0.19, −0.18	−17.1	< 0.001
Female x Disabled	0.02	0.02, 0.06	2.1	0.26	0.09	−0.05, 0.12	9.1	< 0.001
Race/Ethnicity								
White	ref							
Black	−0.06	−0.07, −0.05	−5.5	< 0.001	−0.08	−0.09, −0.07	−7.9	< 0.001
Hispanic	−0.15	−0.16, −0.14	−13.8	< 0.001	−0.17	−0.18, −0.16	−15.5	< 0.001
Asian	−0.20	−0.21, −0.19	−17.9	< 0.001	−0.13	−0.14, −0.11	−11.8	< 0.001

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Table 2 (*continued*)

b. Inner ring & suburb

Variable	*Model 3:*				*Model 4:*			
	Inner Ring				*Suburb*			
	Estimate	95% CI	Percent	P-Value	Estimate	95% CI	Percent	P-Value
Educational Attainment								
Less than HS	−0.30	−0.31, −0.29	−26.0	< 0.001	−0.31	−0.32, −0.29	−26.5	< 0.001
HS to Associate's Degree	ref							
Bachelor's Degree or Higher	0.47	0.46, 0.48	60.2	< 0.001	0.46	0.45, 0.46	57.8	< 0.001
Marital Status								
Married	0.11	0.11, 0.12	12.0	< 0.001	0.25	0.24, 0.25	28.2	< 0.001
Not Married	ref							
Work Status								
Part-Time	−0.23	−0.24, −0.22	−20.4	< 0.001	−0.35	−0.36, −0.34	−29.4	< 0.001
Full-Time	ref							
Public Assistance Recipient								
Yes	−0.28	−0.32, −0.24	−24.4	< 0.001	−0.19	−0.24, −0.14	−17.3	< 0.001
No	ref							
Public Transit Use								
Yes	−0.10	−0.10, −0.09	−9.1	< 0.001	−0.08	−0.09, −0.07	−7.6	< 0.001
No	ref							
Work Location in Manhattan (at PUMA-level)								
Yes	0.19	0.19, 0.20	21.5	< 0.001	0.27	0.26, 0.29	31.3	< 0.001
No	ref							
Home Location (at PUMA-level)								
In Center								
In Inner Ring								
In Suburbs								
Age (years)	0.01	0.01, 0.01	1.0	< 0.001	0.01	0.01, 0.01	1.1	< 0.001
Commute Time (minutes)	0.001	0.001, 0.001	0.1	< 0.001	0.003	0.003, 0.003	0.3	< 0.001
Random Effects								
PUMA-Level Intercept	0.009	0.006, 0.013	0.9		0.004	0.003, 0.006	0.4	
R^2 (marginal)		0.253				0.340		
R^2 (conditional)		0.268				0.346		
AIC		288,962.2				416,671.4		
BIC		289,140.2				416,855.5		

less than workers without disabilities. The large wage disparity coupled with the high cost of living in Manhattan minimizes the gains for workers with disabilities in Manhattan relative to those who live elsewhere in the New York metropolitan region. While residents outside Manhattan have poorer geographic access to good jobs and earn lower absolute wages, they have lower housing costs (Quintana, 2018). The disability pay gap can have pernicious effects on the economic well-being of residents with disabilities. A lower wage may entail a reduced capacity to accumulate wealth and maintain financial stability. Workers navigating the low wage labor market are particularly vulnerable as lower wages entrap them in a cycle of poverty (Jolly, 2013).

3.2.2. Race/ethnicity, gender, and other covariates

Across the metropolitan region, we find significant wage gaps along other social axes of difference, including race/ethnicity and gender (Table 2a, Model 1). In our sample, all racialized minority workers earn much less than white workers, but the wage differences vary by group. Hispanic and Asian workers have the highest wage disparities at 15% lower wages while black workers have the lowest wage disparity with 7% lower wages than white workers. Female workers earn 14% less than male workers. These results corroborate those of recent studies demonstrating that racialized minorities and women earn lower wages, thus facing greater pay discrimination in the labor market than white men (McLafferty and Preston, 2019; Brucker and Rollins 2019).

Transportation mode, level of education, marital status, work status (part-time versus full-time), public assistance status, work location, and residential location also influence wage disparities (Table 2a, Model 1). Public transit users earn 7% less than workers utilizing other transportation options, mainly driving. Workers with a bachelor's degree or higher level of education earn 61% more in hourly wages compared to those with no bachelor's degree. Married workers earn 21% more than workers who are not married. Part-time employees earn 26% less than full-time employees. Public assistance recipients earn 23% less than non-recipients. Approximately 0.5% of non-disabled workers receive public assistance while 1.4% of disabled workers receive public assistance. For all workers, the average total public assistance income in the past 12 months was $3972. Manhattan workers earn 23% more than those who work in the inner ring and suburbs. Compared to suburban residents, center residents earn 1.5% more and inner ring residents earn 8% less. Our findings are consistent with previous studies examining wage disparities by transport mode, level of education, and residential location (e.g., Preston and McLafferty, 2016; Brucker and Rollins 2019; Gunderson and Lee, 2016). The inclusion of disability as a covariate does not alter the directions of the relationships between wages and other socioeconomic and geographic characteristics.

Intraurban patterns generally reflect the trends at the metropolitan scale with a couple of exceptions. In the center, public transit use does not approach statistical significance (Table 2a, Model 1). This is likely because public transit use is common in Manhattan for workers across the wage spectrum and along other axes of social difference (Preston and McLafferty, 2016). The share of the total variance explained by the random effects (i.e., the varying PUMA-level intercepts), differs markedly between the metropolitan region, center, and suburbs. At the scale of the metropolitan region, the proportion is 1.4%. In contrast, the proportion is highest in the center (3.2%) and lowest in the suburbs (0.6%). These findings indicate the importance of distinguishing central transit hubs from other intraurban zones and accounting for different levels in nested data.

Table 3
LMM results with commute time as the dependent variable.

a. Metro & center

Variable	*Model 1: Entire Metro*			*Model 2: Center*		
	Estimate	95% CI	P-Value	Estimate	95% CI	P-Value
Fixed Effects						
Disability Status						
Yes	0.97	0.56, 1.37	< 0.001	3.86	2.53, 5.18	< 0.001
No	ref					
Race/Ethnicity & Gender						
White Male	ref					
White Female	−4.23	−4.43, −4.04	< 0.001	0.67	0.08, 1.25	0.03
Black Female	1.33	1.00, 1.67	< 0.001	1.25	0.15, 2.37	0.03
Black Male	2.15	1.78, 2.52	< 0.001	1.78	0.57, 3.00	0.004
Hispanic Female	−1.33	−1.64, −1.01	< 0.001	0.44	−0.50, 1.39	0.36
Hispanic Male	0.59	0.28, 0.89	< 0.001	0.64	−0.32, 1.61	0.20
Asian Female	−0.62	−0.98, −0.26	< 0.001	0.68	−0.27, 1.63	0.16
Asian Male	2.37	2.03, 2.72	< 0.001	0.95	−0.06, 1.97	0.07
Educational Attainment						
Less than HS	−0.13	−0.43, 0.17	0.40	0.72	−0.35, 1.78	0.19
HS to Associate's Degree	ref					
Bachelor's Degree or Higher	1.93	1.76, 2.11	< 0.001	−0.43	−1.06, 0.19	0.17
Marital Status						
Married	1.04	0.87, 1.20	< 0.001	0.36	−0.13, 0.85	0.15
Not Married	ref					
Work Status						
Part-Time	−4.42	−4.65, −4.20	< 0.001	−0.61	−1.36, 0.14	0.11
Full-Time	ref					
Public Assistance Recipient						
Yes	2.51	1.52, 3.50	< 0.001	3.26	0.63, 5.89	0.02
No	ref					
Public Transit Use						
Yes	23.70	23.48, 23.93	< 0.001	13.70	13.23, 14.17	< 0.001
No	ref					
Work Location in Manhattan (at PUMA-level)						
Yes	11.43	11.20, 11.67	< 0.001	−19.98	−20.58, −19.39	< 0.001
No	ref					
Home Location (at PUMA-level)						
In Center	−22.83	−25.62, −20.03	< 0.001			
In Inner Ring	−4.53	−5.56, −3.49	< 0.001			
In Suburbs	ref					
Age (years)	0.04	0.03, 0.04	< 0.001	0.07	0.05, 0.08	< 0.001
Log Hourly Wage	2.77	2.66, 2.88	< 0.001	−0.72	−1.00, −0.43	< 0.001
Random Effects						
PUMA-Level Intercept	18.14	14.55, 23.25		5.90	2.79, 19.66	
R^2 (marginal)	0.268			0.245		
R^2 (conditional)	0.293			0.259		
AIC	3,395,665			205,250.4		
BIC	3,395,903			205,412.1		

b. Inner ring & suburb

Variable	*Model 3: Inner Ring*			*Model 4: Suburb*		
	Estimate	95% CI	P-Value	Estimate	95% CI	P-Value
Fixed Effects						
Disability Status						
Yes	1.63	1.02, 2.24	< 0.001	0.19	−0.37, 0.75	0.50
No						
Race/Ethnicity & Gender						
White Male						
White Female	−2.65	−3.03, −2.27	< 0.001	−4.25	−4.48, −4.01	< 0.001
Black Female	2.56	2.10, 3.03	< 0.001	0.24	−0.31, 0.78	0.40
Black Male	3.04	2.54, 3.54	< 0.001	1.38	0.78, 1.98	< 0.001
Hispanic Female	−0.65	−1.10, −0.19	0.006	−2.23	−2.71, −1.76	< 0.001
Hispanic Male	1.12	0.67, 1.57	< 0.001	0.22	−0.23, 0.68	0.33
Asian Female	0.59	0.06, 1.12	0.03	−1.09	−1.62, −0.55	< 0.001
Asian Male	2.90	2.39, 3.41	< 0.001	1.80	1.30, 2.30	< 0.001

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Table 3 (*continued*)

b. Inner ring & suburb

	Model 3: *Inner Ring*			*Model 4:* *Suburb*		
Variable	Estimate	95% CI	P-Value	Estimate	95% CI	P-Value
Educational Attainment						
Less than HS	0.65	0.26, 1.05	0.001	−2.25	−2.72, −1.78	< 0.001
HS to Associate's Degree						
Bachelor's Degree or Higher	1.02	0.74, 1.30	< 0.001	2.23	2.01, 2.46	< 0.001
Marital Status						
Married	0.37	0.12, 0.62	0.003	0.76	0.53, 0.99	< 0.001
Not Married						
Work Status						
Part-Time	−2.42	−2.78, −2.06	< 0.001	−5.44	−5.73, −5.14	< 0.001
Full-Time						
Public Assistance Recipient						
Yes	1.51	0.20, 2.82	0.02	1.78	0.17, 3.39	0.03
No						
Public Transit Use						
Yes	21.22	20.93, 21.51	< 0.001	25.23	24.81, 25.65	< 0.001
No						
Work Location in Manhattan (at PUMA-level)						
Yes	7.05	6.74, 7.35	< 0.001	24.87	24.44, 25.30	< 0.001
No						
Home Location (at PUMA-level)						
In Center						
In Inner Ring						
In Suburbs						
Age (years)	0.04	0.03, 0.05	< 0.001	0.02	0.01, 0.02	< 0.001
Log Hourly Wage	1.27	1.09, 1.44	< 0.001	3.44	3.30, 3.59	< 0.001
Random Effects						
PUMA-Level Intercept	18.94	13.64, 28.07		16.57	12.23, 23.73	
R^2 (marginal)	0.246			0.333		
R^2 (conditional)	0.274			0.354		
AIC	1,314,189			1,852,645		
BIC	1,314,387			1,852,849		

3.3. Commute time disparities

3.3.1. Disability

Across the New York metropolitan region, after controlling for transit use, age, and other factors influencing commute time, there is a significant difference between workers with and without disabilities even though the coefficient estimates are notably small. The commute time for workers with disabilities is nearly one minute longer than that for similar workers without disabilities (Table 3a, Model 1). Our small coefficient estimates align with prior studies that found differences that were small or not statistically significant in the commuting patterns of disabled workers compared to non-disabled workers or by disability type at the state and national scales. Deka and Lubin (2012) compared commute time disparities between New Jersey residents with and without disabilities and found small differences, and Brucker and Rollins (2019) found differences that did not reach statistical significance for a representative sample of the entire U.S. population. In Canada, Farber and Páez (2010) found that disability type did not have a sizeable influence on commute distance.

Although differences in commute time for the whole study area are small, we find notable variation among intraurban zones after economic and demographic variables are controlled for. Compared to commuters with no disabilities, commuters with disabilities living in the center travel nearly four minutes longer (Table 3a, Model 2) and those living in the inner ring travel 1.6 min longer (Table 3b, Model 3), which represent nearly 13% and 5% of the median commute time, respectively. In contrast, commute time differences do not reach statistical significance in the suburbs (Table 3b, Model 4), which suggests that having a disability does not have a considerable influence on travel times for suburban residents. These findings extend those of extant research on national and state-level trends (e.g., Brucker and Rollins 2019; Deka and Lubin, 2012; Farber and Páez, 2010) by demonstrating geographic heterogeneity in commuting disparities within a large metropolitan region based on disability status. We find that commute times for disabled workers are longest on average in the center relative to the rest of the region, a finding that would have been masked had our analysis only took place at the scale of the metropolitan region.

3.3.2. Race/ethnicity, gender, and other covariates

At the metropolitan scale, white, Hispanic, and Asian women have shorter commute times than comparable white men, while black women have a longer commute time (Table 3a, Model 1). Black, Hispanic, and Asian men also have longer commute times compared to white men. Our findings on gender differences confirm those of earlier studies that found that men had longer commute times on average than women (Preston and McLafferty, 2016; Craig and van Tienoven, 2019; Brucker and Rollins 2019; Kim et al., 2012). Our results on commute time disparities by race/ethnicity are also consistent with earlier research showing that minorities are more likely to have long work commutes (Brucker and Rollins 2019; Deka and Lubin, 2012). The exception is black women. Their long commute times suggest that they may be less able than other groups of workers to find work close to home and accommodate gendered household responsibilities (Preston and McLafferty, 2016).

We also find significant differences in commute time by travel mode, work location, residential location, educational attainment, public assistance status, and wage earnings. All else being equal, the average one-way commute time of public transit users is 24 min longer than that of non-public transit users. Ceteris paribus, individuals who work in Manhattan commute 11 min longer than people who work elsewhere in the metropolitan region, with commute times varying based on where workers live. Workers residing in the suburbs have the longest commutes. Compared to workers living in the suburbs, workers residing in the center travel 23 fewer minutes and those residing in the inner ring travel 4.5 fewer minutes. Workers with a bachelor's degree or higher education have a longer commute time (1.9 min) than workers with less education. Public assistance recipients travel 2.5 min longer than non-recipients. Log hourly wages are positively correlated with commute time which indicates that overall, workers trade longer commute times to secure higher-wage employment. This fortifies what we already know – that workers who use public transit, have higher levels of education, and higher wages travel longer to get to work (Preston and McLafferty, 2016; Brucker and Rollins 2019).

The variance in commute time attributable to the fixed and random effects differs slightly by intraurban zone. The share of the total variance explained by the fixed effects is highest in the suburbs (33.3%) while similar among the other geographies (ranging from 24.5–26.8%). The proportion attributable to the random effects is lowest in the center (1.4%) while over 2% for the metro, inner ring, and suburbs (ranging from 2.1–2.8%). The variances explained by the varying PUMA-level intercepts are sizeable relative to the variances explained by all model parameters (proportions range from 6 to 10%), indicating the importance of accounting for nested data in statistical models.

3.4. Commute time and wage trade-offs for workers with disabilities

This section focuses on workers with disabilities alone to identify trends specific to having a disability. When using LMMs to analyze commute times among workers with disabilities, we find that people are generally taking on longer commutes for higher wages across the study area (Table 4a, Model 1). On average, workers with disabilities travel three minutes longer (representing 10% of the median commute time) for each one-unit increase in log hourly wage. Then when we look closely at gender and race/ethnicity, we find that white and Hispanic women have significantly shorter commute times (four and 2.4 min shorter, respectively) than comparable white men. Similar disparities exist in the models for the suburbs and inner ring. Among white workers with disabilities, women have shorter commutes than comparable men, reinforcing the gender gap in commuting seen in previous studies of the white population overall (Preston and McLafferty, 2016; Crane, 2007). The significantly shorter commute time among Hispanic women is unexpected. Previous research at the state and national scales suggests that racialized minority workers with disabilities have commutes that are not significantly different from those of white, male workers (Deka and Lubin, 2012; Farber and Páez, 2010). Further investigation is needed to better understand this finding. Specifically, we speculate whether white and Hispanic women with disabilities are more likely than black women to live in neighborhoods where public transportation and job opportunities are more accessible (Wong, 2018a).

The need to consider the geographic contexts in which people with disabilities live is underscored by notable differences across the intraurban zones in the variance in commute time that is attributable to the fixed and random effects. The share of the total variance explained by the fixed effects is highest in the suburbs (27.7%) and lowest in the center (20.9%). The proportion attributable to the random effects is highest in the inner ring (2.5%) while negligible in the center (0.02%).

Commuting via public transit lengthens the work trips of workers with disabilities in all geographic contexts, from 18.5 min in the center to 23 min in the suburbs and inner ring (Table 4). For those who rely on public transit to get to work, access barriers in the region's subway and bus systems may result in longer travel times for workers with disabilities (Bezyak et al., 2017; Deka and Lubin, 2012; Farber and Páez, 2010). For disabled workers, we see reduced public transit use (and thus increased private vehicle use) from the center outward (Table 1), a trend that is consistent with disabled workers' efforts to minimize public transit constraints (Wong, 2018b).

Our findings of significant gender and minority disparities in commute time for disabled workers differ from those by Farber and Páez (2010), which to our knowledge is the only other study to analyze how sociodemographic factors affect the commuting behavior of people with disabilities alone. Using national-level data, Farber and Páez (2010) found that gender and minority status were not significantly correlated with commute distance for Canadians with disabilities. One way to reconcile the disparate findings is to investigate in more detail how commute distance and commute time are related. People who live further away from their workplaces may travel at faster speeds that mitigate the constraint of distance (Farber and Páez, 2010) and result in commute times similar to those of residents who live closer to work.

Wage and commute time associations at the scale of the metropolitan region are also evident in the inner ring and suburbs, but not in the center. For each one-unit increase in log hourly wage, workers in the inner ring commute 1.3 min more (Table 4b, Model 3) and workers in the suburbs travel 3.8 min longer (Table 4b, Model 4). In the center, the association between wages and commute time does not reach statistical significance (Table 4a, Model 2), possibly reflecting the co-location and high densities of jobs and housing in Manhattan. Previous research on the general population found that the highest paid workers live in Manhattan where commute times are relatively short (Preston and McLafferty, 2016).

Workers with disabilities undertake longer commutes specifically for good jobs in Manhattan. Compared to people working in the inner ring and suburbs, those who work in Manhattan have a longer commute time – 11 min longer on average for the entire metropolitan region. Commute time increases as a function of distance from the center. Inner ring and suburban residents travel longer than Manhattan residents – seven and 28 min, respectively – to jobs in Manhattan (Table 4b). Our findings corroborate what we know about the population at large – on average, workers pursue longer commutes in exchange for higher wages (Preston and McLafferty, 2016; Brucker and Rollins 2019; Morris and Zhou, 2018). The factors that influence the commute times of workers with disabilities are similar to those for the general population. The problem that remains is that workers with disabilities are unable to make up the wage gap with longer commute times (Brucker and Rollins 2019).

4. Conclusion

Our study generates new geographic insights about the impacts of disability status on wage earnings and commute times for residents in the New York metropolitan region. We extend previous research that examined national-level trends (e.g., Brucker and Houtenville, 2015; Gunderson and Lee, 2016; Schur, 2002) by investigating metropolitan and intraurban patterns. In doing so, we uncover intraurban variability in wages and commute times that would have gone unnoticed had our analysis stopped at the metropolitan scale. When analyzing intraurban trends, we find marked variability in wage gaps between workers with and without disabilities by geographic zone, with the highest wage gaps in the center and suburbs. Regarding commute time, we find that workers with disabilities have significantly longer commutes than workers without disabilities in the center and inner ring, but not in the suburbs. When looking at disabled workers alone, we find that people largely trade higher wages for longer commutes; however, such substitutions are most pronounced among workers who live in the suburbs and inner ring.

Gender disparities in commute time among workers with disabilities largely mimic those observed in studies of the overall population. Some women may have gendered household responsibilities that motivate them to work closer to home so they can spend more time for household purposes (Preston and McLafferty, 2016; Craig and van Tienoven, 2019), and some women with disabilities may restrict their travels for fear of crime and uncomfortable encounters with strangers (Wong,

Table 4
LMM results with commute time as the dependent variable (workers with disabilities only).

a. Metro & center

	Model 1: Entire Metro			Model 2: Center		
Variable	Estimate	95% CI	P-Value	Estimate	95% CI	P-Value
Fixed Effects						
Race/Ethnicity & Gender						
White Male	ref					
White Female	−3.93	−5.04, −2.81	< 0.001	0.66	−4.38, 5.71	0.80
Black Female	1.02	−0.61, 2.67	0.22	5.07	−1.04, 11.25	0.11
Black Male	1.64	−0.31, 3.58	0.10	3.23	−4.46, 10.98	0.42
Hispanic Female	−2.36	−4.04, −0.70	0.006	3.48	−2.21, 9.23	0.24
Hispanic Male	1.24	−0.52, 2.99	0.17	8.12	1.68, 14.61	0.02
Asian Female	−1.82	−4.28, 0.64	0.15	2.03	−6.06, 10.10	0.63
Asian Male	0.41	−2.09, 2.91	0.75	11.98	1.85, 22.09	0.02
Educational Attainment						
Less than HS	0.22	−1.10, 1.55	0.74	2.37	−3.14, 7.87	0.40
HS to Associate's Degree	ref					
Bachelor's Degree or Higher	1.49	0.47, 2.50	0.004	0.10	−3.96, 4.18	0.96
Marital Status						
Married	1.23	0.33, 2.13	0.007	0.94	−2.65, 4.52	0.61
Not Married	ref					
Work Status						
Part-Time	−4.53	−5.58, −3.49	< 0.001	3.80	−0.54, 8.13	0.09
Full-Time	ref					
Public Assistance Recipient						
Yes	3.10	−0.47, 6.68	0.09	−4.92	−15.76, 5.92	0.38
No	ref					
Public Transit Use						
Yes	24.10	22.94, 25.27	< 0.001	18.54	15.09, 22.01	< 0.001
No	ref					
Work Location in Manhattan (at PUMA-level)						
Yes	11.07	9.73, 12.40	< 0.001	−16.76	−20.89, −12.65	< 0.001
No	ref					
Home Location (at PUMA-level)						
In Center	−15.53	−18.85, −12.21	< 0.001			
In Inner Ring	−1.33	−2.99, 0.32	0.12			
In Suburbs	ref					
Age (years)	−0.0004	−0.03, 0.03	0.98	0.06	−0.06, 0.17	0.34
Log Hourly Wage	3.02	2.44, 3.59	< 0.001	0.54	−1.38, 2.45	0.59
Random Effects						
PUMA-Level Intercept	15.12	12.13, 19.38		0.13	0.06, 0.44	
R^2 (marginal)	0.240			0.2088		
R^2 (conditional)	0.260			0.2091		
AIC	118,963.2			6448.42		
BIC	119,120			6535.30		

b. Inner ring & suburb

Variable	Model 3: Inner Ring			Model 4: Suburb		
	Estimate	95% CI	P-Value	Estimate	95% CI	P-Value
Fixed Effects						
Race/Ethnicity & Gender						
White Male	ref					
White Female	−3.73	−5.96, −1.50	0.001	−3.28	−4.55, −2.00	< 0.001
Black Female	0.23	−2.13, 2.60	0.85	1.45	−1.32, 4.21	0.31
Black Male	1.61	−1.15, 4.38	0.25	1.88	−1.25, 5.01	0.24
Hispanic Female	−3.16	−5.65, −0.68	0.01	−2.82	−5.45, −0.21	0.03
Hispanic Male	0.60	−2.00, 3.18	0.65	1.11	−1.56, 3.76	0.42
Asian Female	−2.81	−6.38, 0.78	0.13	−1.62	−5.34, 2.08	0.39
Asian Male	−0.36	−3.88, 3.18	0.84	−0.14	−3.98, 3.68	0.94
Educational Attainment						
Less than HS	0.84	−0.97, 2.66	0.36	−1.74	−3.77, 0.28	0.09
HS to Associate's Degree	ref					
Bachelor's Degree or Higher	0.62	−1.04, 2.29	0.46	1.59	0.28, 2.89	0.02
Marital Status						
Married	−0.51	−1.90, 0.88	0.47	1.76	0.56, 2.96	0.004

(*continued on next page*)

Table 4 (*continued*)

b. Inner ring & suburb

Variable	*Model 3: Inner Ring*			*Model 4: Suburb*		
	Estimate	95% CI	P-Value	Estimate	95% CI	P-Value
Not Married	ref					
Work Status						
Part-Time	−3.18	−4.86, −1.50	< 0.001	−5.63	−6.99, −4.28	< 0.001
Full-Time	ref					
Public Assistance Recipient						
Yes	−0.16	−5.18, 4.87	0.95	9.10	3.58, 14.61	0.001
No	ref					
Public Transit Use						
Yes	23.25	21.71, 24.80	< 0.001	23.20	21.15, 25.25	< 0.001
No	ref					
Work Location in Manhattan						
Yes	7.20	5.48, 8.92	< 0.001	28.16	25.70, 30.62	< 0.001
No	ref					
Home Location						
In Center						
In Inner Ring						
In Suburbs						
Age (years)	0.008	−0.04, 0.06	0.74	−0.01	−0.05, 0.03	0.62
Log Hourly Wage	1.26	0.32, 2.21	0.009	3.84	3.09, 4.60	< 0.001
Random Effects						
PUMA-Level Intercept	19.89	14.33, 29.48		13.19	9.74, 18.89	
R^2 (marginal)	0.229			0.277		
R^2 (conditional)	0.254			0.295		
AIC	50,646.7			61,267.57		
BIC	50,772.26			61,397.04		

2018b). The notable finding is that female workers face an additional wage penalty for having a disability.

It remains important to continue our collective investigations on the commute patterns of workers with disabilities because there is limited empirical evidence. Our paper is one data point that joins only a few other studies (Brucker and Rollins 2019; Deka and Lubin, 2012; Farber and Páez, 2010). More research is needed on disability and work commutes as inaccessible transportation is identified frequently as a critical obstacle to accessing employment and good jobs for people with disabilities (Bezyak et al., 2019; Lubin and Feeley, 2016). We anticipate that work commutes are different for people with disabilities residing in different places across the urban-rural continuum. We also expect varying travel patterns based on disability type and transportation mode. For example, some workers with mobility constraints may live close to their work locations and have short commute times. For workers with disabilities who rely on public transit, we expect long commute times. Such long commute times are borne out in our study of workers with disabilities in the New York region, with its extensive public transit network.

Our findings underscore the need for more accessible and quicker forms of transportation as workers with disabilities are taking on the burden of longer commutes in exchange for higher wages. A more accessible public transportation system also has great potential to improve the mobility and employment rates of people with disabilities. Increasing the availability of centrally located and affordable housing for people with disabilities could also enhance their access to employment. Lower living costs, especially at central locations near job hubs, would help alleviate the disability pay gap and reduce commute time. At the same time, given the current COVID-19 pandemic and the heightened risk of disease exposure from commuting via public transit and working in congregated spaces, the more immediate need may be for policies to support remote work or training for remote jobs. However, since disabled workers are usually overrepresented in service and blue-collar jobs and underrepresented in managerial and professional positions (Kruse et al., 2018; Maroto and Pettinicchio, 2014), they are less likely to have jobs that they can do remotely. For jobs in which working from home is not possible, there is a need for safer public transit commutes and workspaces.

Future research should address the limitations of this study that relies on cross-sectional data and observes trends at one time interval. Longitudinal surveys, while more expensive, would provide richer information about the causal effects of disability over time. For example, Jolly (2013) used longitudinal data to show that having a disability increased workers' financial precarity by increasing the probability of downward mobility in earnings, the likelihood of being at the lower end of the income distribution, and the risk of poverty. More detailed measures of disability that distinguish varying levels of impairment and include people experiencing transitory disability as well as long-term disability would also enhance our understanding of the commutes of workers with disabilities (Myers et al., 2020). Finally, even though the sample for the New York metropolitan region is large, sample sizes for people with disabilities diminish rapidly as we disaggregate by geographic zone. A larger sample would allow even more detailed intraurban analysis.

To our knowledge, ours is the first case study of intraurban wage and commute patterns among disabled workers in a major metropolitan region in the U.S. Future research should study additional metropolitan areas since each region has distinctive housing and labor markets, transportation systems, and intraurban zones. An *inter*-urban comparison would facilitate assessment of differences and similarities in the wage and commuting trends of workers with disabilities and allow us to determine the extent to which findings in the New York metropolitan region are generalizable to other urban regions.

Qualitative or mixed quantitative and qualitative research has the potential to provide additional insight into the commutes of people with disabilities. Qualitative studies of the commuting behavior of all workers imply that some people with disabilities are unlikely to accept a higher wage job if the commute distance is too far or the travel logistics too onerous. For example, one study utilizing mixed methods revealed that Berkeley residents generally desired an acceptable commute time, one that was contingent on people's satisfaction with various aspects of their complete travel experience (Milakis et al., 2015). Another case study in the San Francisco Bay Area also showed that residents with visual impairment sought reasonable work commutes as they navigated their everyday spatiotemporal constraints (Wong, 2018b). Qualitative research would help us ascertain whether the major barriers to employment and high wages are related to personal concerns, type of disability, employer discrimination, or inaccessible built environments and transportation networks. Specific interventions can then be identified for improving the wage earnings, travel logistics, and overall quality of life for working-age people with disabilities.

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Declaration of Competing Interest

None.

References

Bezyak, J.L., Sabella, S.A., Gattis, R.H., 2017. Public transportation: an investigation of barriers for people with disabilities. J. Disabil. Policy Stud. 28 (1), 52–60. https://doi.org/10.1177/1044207317702070.
Bezyak, J.L., Sabella, S., Hammel, J., McDonald, K., Jones, R.A., Barton, D., 2019. Community participation and public transportation barriers experienced by people with disabilities. Disabil. Rehabil. https://doi.org/10.1080/09638288.2019.1590469.
Brauer, M., Curtin, J.J., 2018. Linear mixed-effects models and the analysis of non-independent data: a unified framework to analyze categorical and continuous independent variables that vary within-subjects and/or within-items. Psychol. Methods 23 (3), 389–411. https://doi.org/10.1037/met0000159.
Brucker, D.L., Houtenville, A.J., 2015. People with disabilities in the United States. Arch. Phys. Med. Rehabil. 96 (5), 771–774. https://doi.org/10.1016/j.apmr.2015.02.024.
Brucker, D.L., Rollins, N.G., 2019. The association of commuting time and wages for American workers with disabilities. J. Vocat. Rehabil. 50 (5), 13–21. https://doi.org/10.3233/JVR-180984.
Craig, L., van Tienoven, T.P., 2019. Gender, mobility and parental shares of daily travel with and for children: a cross-national time use comparison. J. Transp. Geogr. 76, 93–102. https://doi.org/10.1016/j.jtrangeo.2019.03.006.
Crane, R., 2007. Is there a quiet revolution in women's travel? Revisiting the gender gap in commuting. J. Am. Plan. Assoc. 73 (3), 298–316. https://doi.org/10.1080/01944360708977979.
Crudden, A., Sansing, W., Butler, S., 2005. Overcoming barriers to employment: strategies of rehabilitation providers. J. Visual Impairm. Blind. 99 (6), 325–335. https://doi.org/10.1177/0145482x0509900602.
Deka, D., Lubin, A., 2012. Exploration of poverty, employment, earnings, job search, and commuting behavior of persons with disabilities and African-Americans in New Jersey. Transp. Res. Rec. 2320 (1), 37–45. https://doi.org/10.3141/2320-05.
Eisenberg, Y., Heider, A., Gould, R., Jones, R., 2020. Are communities in the United States planning for pedestrians with disabilities? Findings from a systematic evaluation of local government barrier removal plans. Cities 102. https://doi.org/10.1016/j.cities.2020.102720.
England, K., 2003. Disabilities, gender and employment: social exclusion, employment equity and Canadian banking. Can. Geogr. 47 (4), 429–450. https://doi.org/10.1111/j.0008-3658.2003.00034.x.
Farber, S., Páez, A., 2010. Employment status and commute distance of Canadians with disabilities. Transportation 37 (6), 931–952. https://doi.org/10.1007/s11116-010-9268-y.
Gelman, A., Hill, J., 2007. Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge University Press, Cambridge.
Gewurtz, R.E., Langan, S., Shand, D., 2016. Hiring people with disabilities: a scoping review. Work 54 (1), 135–148. https://doi.org/10.3233/WOR-162265.
Gleeson, B., 1999. Geographies of Disability. Routledge, London and New York.
Gunderson, M., Lee, B.Y., 2016. Pay discrimination against persons with disabilities: Canadian evidence from PALS. Int. J. Hum. Resour. Manag. 27 (14), 1531–1549. https://doi.org/10.1080/09585192.2015.1072106.
Hanson, S., Pratt, G., 1995. Gender, Work, and Space. Routledge, London and New York.
Hu, L., 2015. Job accessibility of the poor in Los Angeles: has suburbanization affected spatial mismatch? J. Am. Plan. Assoc. 81 (1). https://doi.org/10.1080/01944363.2015.1042014.
Ingraham, C., 2019. Nine days on the road. Average commute time reached a new record last year. Wash. Post. https://www.washingtonpost.com/business/2019/10/07/nine-days-road-average-commute-time-reached-new-record-last-year/.
Johnston-Anumonwo, I., 2014. Women's work trips and multifaceted oppression. In: Asumah, S.N., Nagel, M. (Eds.), Diversity, Social Justice, and Inclusive Excellence. State University of New York Press, Albany, pp. 93–112.
Jolly, N.A., 2013. The impact of work-limiting disabilities on earnings and income mobility. Appl. Econ. 45 (36), 5104–5118. https://doi.org/10.1080/00036846.2013.818212.
Kaye, H.S., 2010. The impact of the 2007-2009 recession on workers with disabilities. U.S. Department of Labor, Bureau of Labor Statistics. Month. Lab. Rev. 133 (10), 19–30.
Kim, C., Sang, S., Chun, Y., Lee, W., 2012. Exploring urban commuting imbalance by jobs and gender. Appl. Geogr. 32 (2), 532–545. https://doi.org/10.1016/j.apgeog.2011.07.001.
Kruse, D., Schur, L., Rogers, S., Ameri, M., 2018. Why do workers with disabilities earn less? Occupational job requirements and disability discrimination. Br. J. Ind. Relat. 56 (4), 798–834. https://doi.org/10.1111/bjir.12257.
Lee, J., Vojnovic, I., Grady, S.C., 2018. The 'transportation disadvantaged': urban form, gender and automobile versus non-automobile travel in the Detroit region. Urban Stud. 55 (11), 2470–2498. https://doi.org/10.1177/0042098017730521.
Lindsay, C., Houston, D., 2011. Fit for purpose? Welfare reform and challenges for health and labour market policy in the UK. Environ. Plan. A 43 (3), 703–721. https://doi.org/10.1068/a43442.
Loprest, P., Maag, E., 2001. Barriers to and Supports for Work among Adults with Disabilities: Results from the NHIS-D. The Urban Institute. https://aspe.hhs.gov/basic-report/barriers-and-supports-work-among-adults-disabilities-results-nhis-d.
Lubin, A., Feeley, C., 2016. Transportation issues of adults on the autism spectrum: findings from focus group discussions. Transp. Res. Rec. 2542, 1–8. https://doi.org/10.3141/2542-01.
Lubin, A., Deka, D., 2012. Role of Public Transportation as Job Access Mode: Lessons from Survey of People with Disabilities in New Jersey. Transp. Res. Rec: J. Trans. Res. Board 2277, 90–97. https://doi.org/10.3141/2277-11.
Maroto, M., Pettinicchio, D., 2014. Disability, structural inequality, and work: the influence of occupational segregation on earnings for people with different disabilities. Res. Soc. Stratif. Mobil. 38, 76–92. https://doi.org/10.1016/j.rssm.2014.08.002.
Maroto, M., Pettinicchio, D., 2015. Twenty-five years after the ADA: situating disability in America's system of stratification. Disabil. Stud. Quart. 35 (3), 1–35. https://dsq-sds.org/article/view/4927/4024.
Mauch, M., Taylor, B.D., 1997. Gender, race, and travel behavior: analysis of household-serving travel and commuting in the San Francisco Bay Area. Transp. Res. Rec. 1607 (1), 147–153. https://doi.org/10.3141/1607-20.
McLafferty, S., Preston, V., 1992. Spatial mismatch and labor market segmentation for Black and Latina women. Economic Geography 684, 406–431. https://doi.org/10.2307/144026.
McLafferty, S., Preston, V., 2019. Who has long commutes to low-wage jobs? Gender, race, and access to work in the New York region. Urban Geography 409, 1270–1290. https://doi.org/10.1080/02723638.2019.1577091.
McNeish, D., Kelley, K., 2019. Fixed effects models versus mixed effects models for clustered data: reviewing the approaches, disentangling the differences, and making recommendations. Psychol. Methods 24 (1), 20–35. https://doi.org/10.1037/met0000182.
Milakis, D., Cervero, R., van Wee, B., Maat, K., 2015. Do people consider an acceptable travel time? Evidence from Berkeley, CA. J. Transp. Geogr. 44, 76–86. https://doi.org/10.1016/j.jtrangeo.2015.03.008.
Mitra, S., Posarac, A., Vick, B.C., 2011. Disability and poverty in developing countries: a snapshot from the world health survey. SSRN Electron. J. https://doi.org/10.2139/ssrn.1908128.
Morris, E., Zhou, Y., 2018. Are long commutes short on benefits? Commute duration and various manifestations of well-being. Travel Behav. Soc. 11, 101–110. https://doi.org/10.1016/j.tbs.2018.02.001.
Moss, M.L., Qing, C.Y., Kaufman, S., 2012. Commuting to Manhattan: A Study of Residence Location Trends for Manhattan Workers from 2002 to 2009. Rudin Center for Transportation Policy, New York University, New York.
Myers, A., Ward, B., Wong, J., Ravesloot, C., 2020. Health status changes with transitory disability over time. Soc. Sci. Med. 244. https://doi.org/10.1016/j.socscimed.2019.112647.
Nakagawa, S., Johnson, P.C.D., Schielzeth, H., 2017. The coefficient of determination R^2 and intra-class correlation coefficient from generalized linear mixed-effects models revisited and expanded. J. R. Soc. Interface 14, 20170213. https://doi.org/10.1098/rsif.2017.0213.
Preston, V., McLafferty, S., 2016. Revisiting Gender, Race, and Commuting in New York. Annals of the Association of American Geographers 57, 1–11. https://doi.org/10.1080/00045608.2015.1113118.
Quintana, M., 2018. Earn More, Pay Less? Average Housing Costs and Incomes by NYC Borough. https://streeteasy.com/blog/cost-of-living-nyc-income-housing-all-5-boroughs/.
Sarrett, J., 2017. Interviews, disclosures, and misperceptions: autistic adults' perspectives on employment related challenges. Disabil. Stud. Quart. 37 (2). https://doi.org/10.18061/dsq.v37i2.5524.
Schur, L., 2002. The difference a job makes: the effects of employment among people with disabilities. J. Econ. Issues 36 (2), 339–347. https://doi.org/10.1080/00213624.2002.11506476.
Sevak, P., Houtenville, A.J., Brucker, D.L., O'Neill, J., 2015. Individual characteristics and the disability employment gap. J. Disabil. Policy Stud. 26 (2), 80–88. https://doi.org/10.1177/1044207315585823.
Subramanian, S.V., Jones, K., Duncan, C., 2003. Multilevel models for public health research. In: Kawachi, I., Berkman, L.F. (Eds.), Neighborhoods and Health. Oxford University Press, Oxford, pp. 65–111.
Sultana, S., Weber, J., 2014. The nature of urban growth and the commuting transition:

endless sprawl or a growth wave? Urban Stud. 51 (3), 544–576. https://doi.org/10.1177/0042098013498284.
U.S. Census Bureau, 2010. State and Metropolitan Area Data Book: 2010. https://www.census.gov/prod/2010pubs/10smadb/2010smadb.pdf.
U.S. Census Bureau, 2013. Census Bureau Reports 1.6 Million Workers Commute into Manhattan Each Day. https://www.census.gov/newsroom/press-releases/2013/cb13-r17.html.
Vornholt, K., Villotti, P., Muschalla, B., Bauer, J., Colella, A., Zijlstra, F., Van Ruitenbeek, G., Uitdewilligen, S., Corbière, M., 2018. Disability and employment – overview and highlights. Eur. J. Work Org. Psychol. 27 (1), 40–55. https://doi.org/10.1080/1359432x.2017.1387536.
Wong, S., 2018a. The limitations of using activity space measurements for representing the mobilities of individuals with visual impairment: A mixed methods case study in the San Francisco Bay Area. Journal of Transport Geography 66, 300–308. https://doi.org/10.1016/j.jtrangeo.2017.12.004.
Wong, S., 2018b. Traveling with Blindness: A Qualitative Space-Time Approach to Understanding Visual Impairment and Urban Mobility. Health & Place 49, 85–92. https://doi.org/10.1016/j.healthplace.2017.11.009.